Acquisition Support:
Helping Programs Succeed

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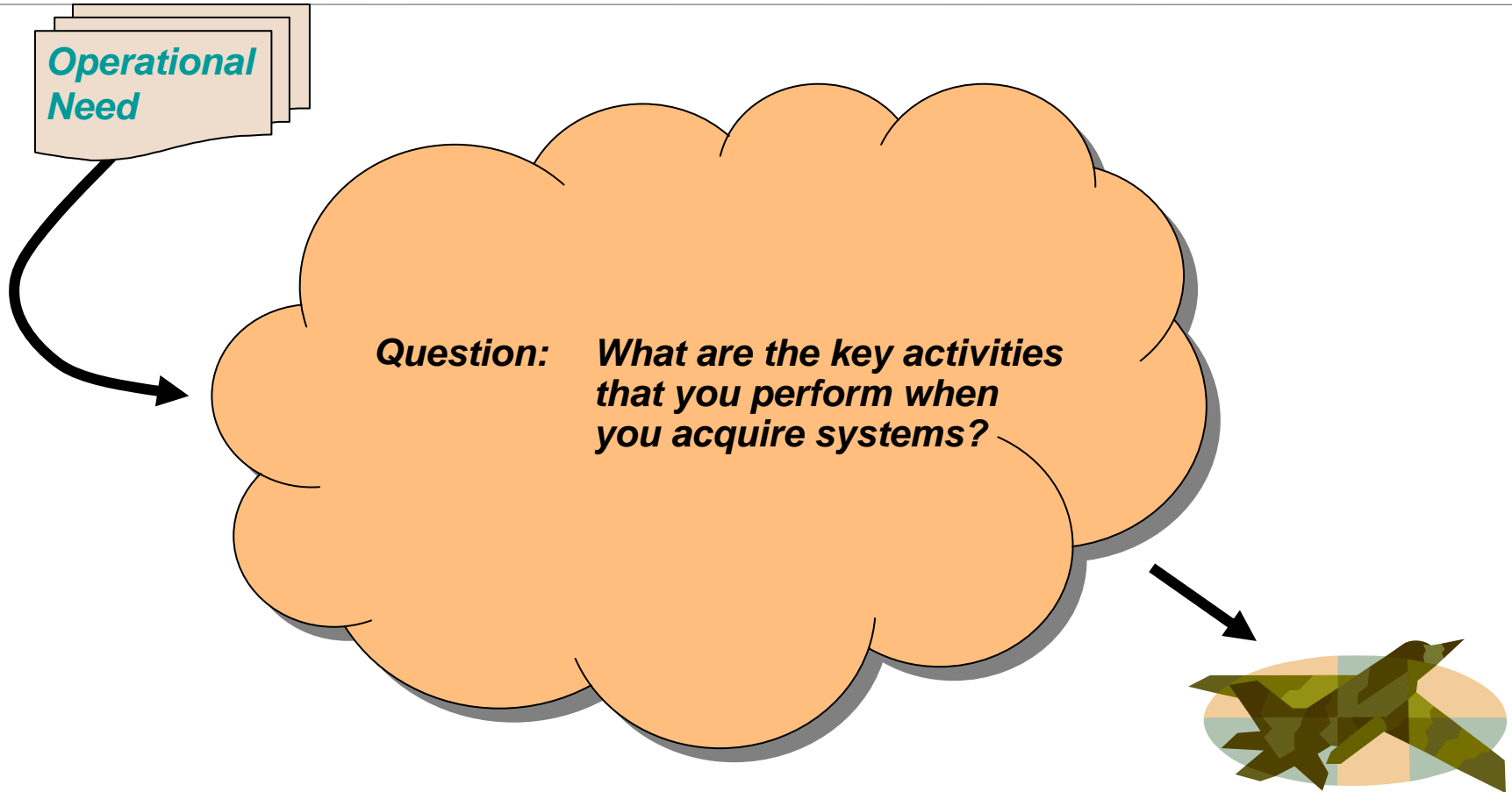
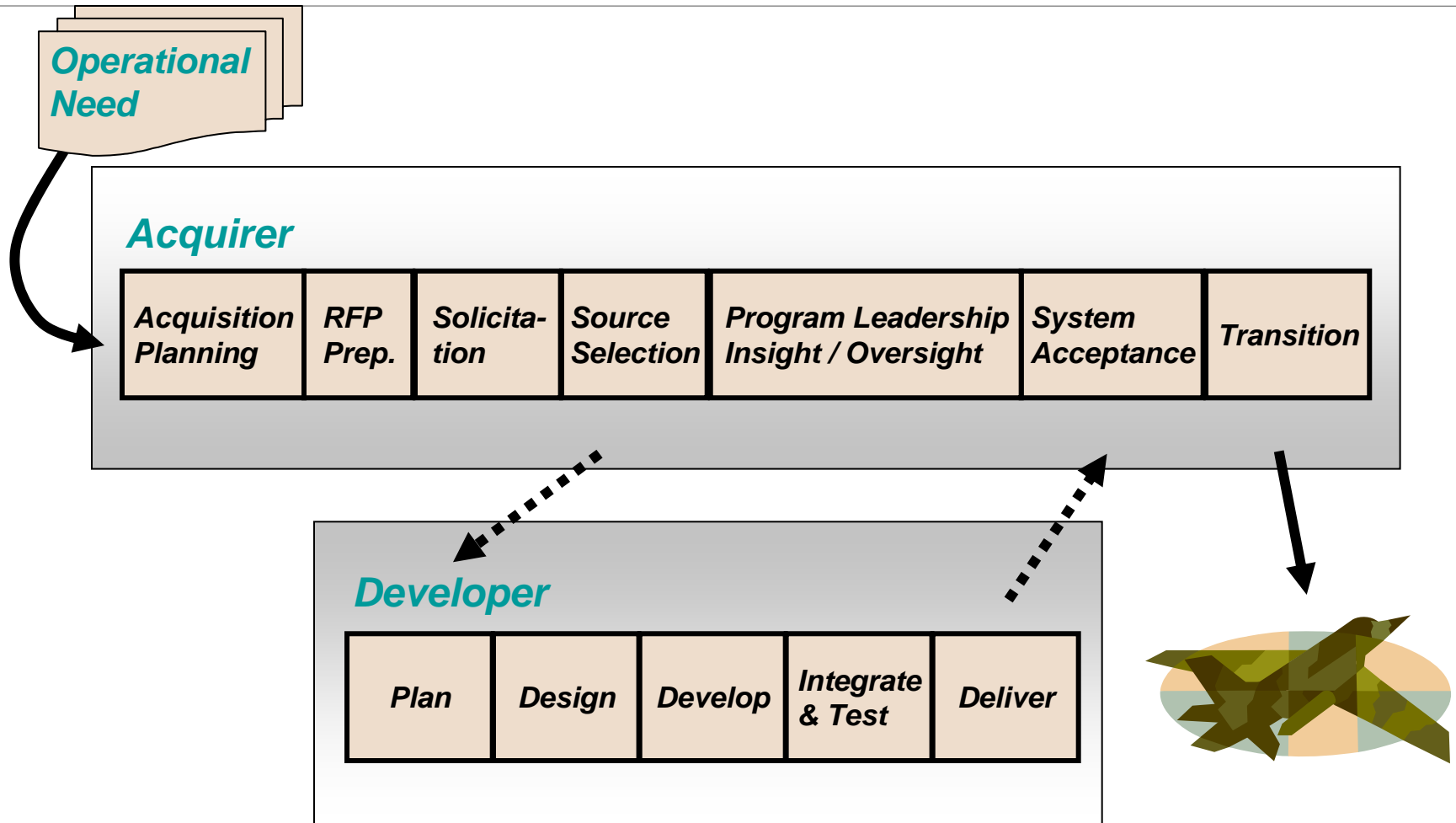Carnegie Mellon University

Pittsburgh, PA 15213

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What is "Acquisition"

Operational Need

Question: What are the key activities that you perform when you acquire systems?

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A Strategic Partnership

Operational Need

Acquirer

Acquisition Planning	RFP Prep.	Solicita-tion	Source Selection	Program Leadership Insight / Oversight	System Acceptance	Transition

Developer

Plan	Design	Develop	Integrate & Test	Deliver

Acquisition Support Program Mission

Drawing on our expertise in software engineering, help DoD, federal agency, and other acquirers continuously improve and institutionalize their ability to acquire, deploy, and sustain systems and capabilities.

Identify opportunities for the Software Engineering Institute (SEI) to create, apply, and amplify technologies that respond to customer needs.

Disseminate lessons learned and best practices through courses, workshops, conferences, publications, and participation in acquisition communities of practice.

Strategies

Impact individual programs

Impact acquisition organizations

Define, integrate, and transfer knowledge

ASP Operational Plan

Acquisition Support Program *applies*

Software and Systems Technologies

Feedback from direct support and community learning improves ASP practices & SEI technologies

Direct Benefit *to* **Acquisition Programs**

Indirect Benefit *to* **Similar Programs**

- *Workshops, Classes, Seminars*

- *Tailored learning via Acquisition Communities of Practice*
  - **Army, Navy, Air Force, Defense and Intel Agencies**
  - **Software Collaborator's Network**
  - **Conferences**
  - **MITRE, Aerospace**
  - **Defense Acquisition University**
  - **OSD Best Practices**
  - **Civil Agencies**
  - **Universities**
  - **US-UK-AUS Working Groups**

ASP Areas of Work

S/W Engineering

Systems Engineering

Process

Mission Assurance

Architecture

Interoperability

Security

Department of Defense Programs

Civilian Agency Programs

Knowledge Integration, and Transfer

Improved Systems

Improved State of Practice
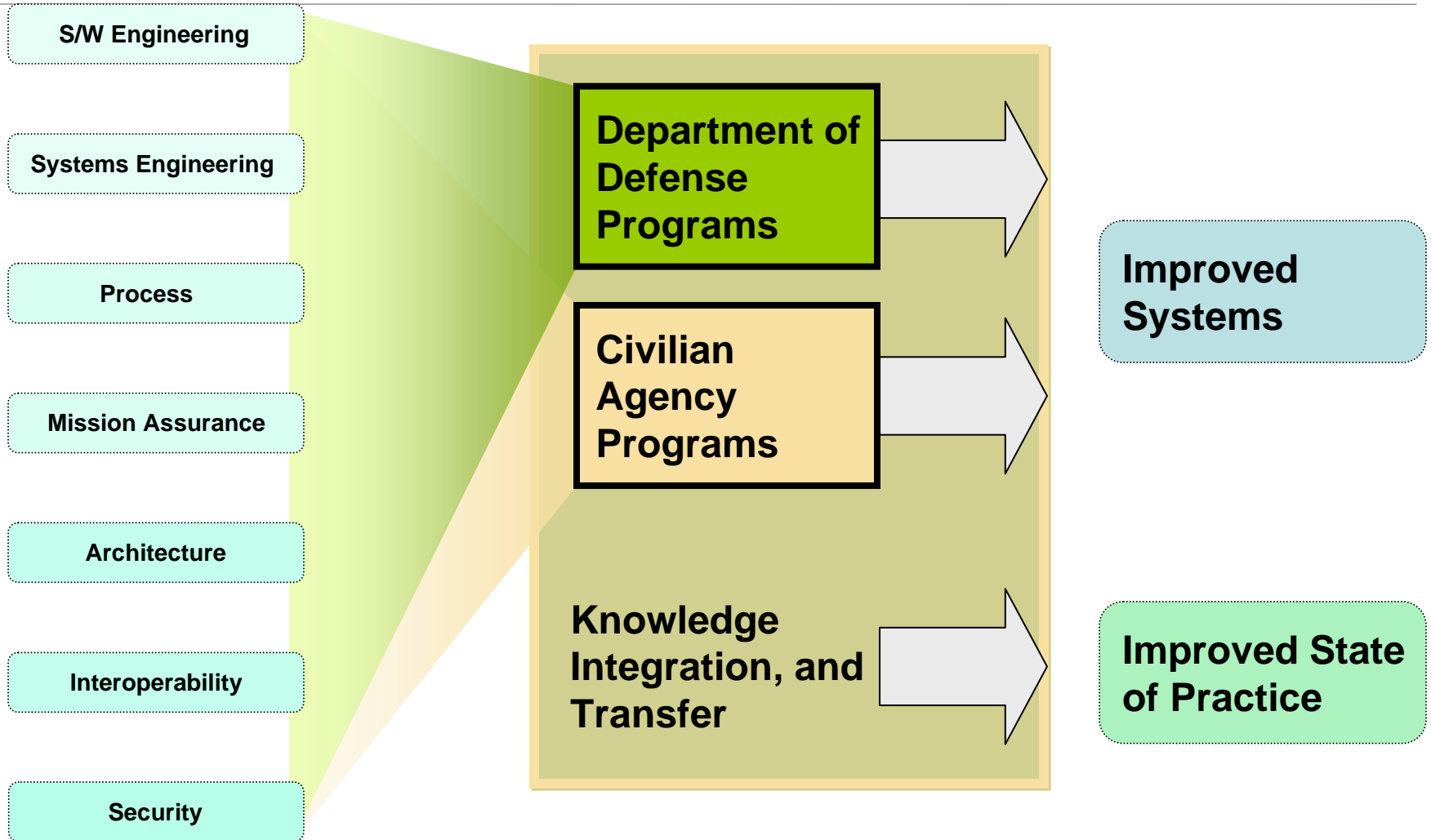
Sampling of Customers

Army

- AMC G-6
- AMRDEC SED
- ASA(ALT)
- CECOM SEC
- PEO Aviation
- PEO Soldier
- PM Future Combat Systems
- PM Integrated Fire Control

Navy

- Common Link Integrated Processor
- DDG-1000
- F/18
- SPAWAR PMW 146-San Diego
- SPAWAR Systems Center-Charleston

Civil Agencies

- Dept. of Interior
- Dept. Veterans Affairs
- Nuclear Regulatory Commission
- NASA
- US Coast Guard

Joint/Other DoD

- DFAS
- Joint Strike Fighter
- JTRS
- MDA
- NSPS
- SIAP JPO

Intelligence Agencies

- DHS
- National Geospatial Intelligence Agency
- NRO
- NSA
- GCHQ
- DIA

Air Force

- AEHF
- AFRL
- CCS-C
- Cyberspace Task Force
- FAB-T
- GCSS-AF
- GPS
- HRC2SPO
- JMPS
- KG-3X
- MEECN
- SAF/AQ
- SMC/AX
- Space Radar
- TBMCS
- TSAT
- WEEMC
- SBIRS

ASP Army Team

Chief Engineer: Cecilia Albert

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ASP Army Team – Strategy

Impact Acquisition Orgs

- Work across the Army through ASA/ALT to "dramatically improve the acquisition of software-intensive systems"

- Work with selected PEOs to implement improvements across their organizations

Impact Individual Programs

- Work with selected PMs to help them be more effective and demonstrate the utility of "best" software engineering practices

Define, Integrate, and Transfer Knowledge

- Help Software Engineering Centers become transition partners for providing software engineering services to Army PMs

- Help define Army needs for software engineering technology

Army Example Engagement Results[1]
Adaptive Planning Tool Migration to NECC

Task:

- Define an acceptable transition path for rapidly transitioning proven ACTD/JCTDs into operational capability through NECC as the program of record

Strategy:

- Use Quality Attribute Workshop to define architecturally significant scenarios

- Use the Service-Oriented Migration and Reuse Technique (SMART) to evaluate candidate tools in the context of NECC

- Define a "fast track" process to take advantage of ACTD capabilities to rapidly (and cheaply?) deliver operational capability through NECC

Army Example Engagement Results[2]
Adaptive Planning Tool Migration to NECC

Accomplishments:

- Worked with JFCOM and JCS/J-9 to understand operational needs

- Worked with NECC to understand critical evidence required for entrance

- Examined 8 individual products for applicability

- Developed a high level functional architecture using 3 products

Next Steps:

- Continue dialogue with customers and NECC

- Define interoperability requirements across the 3 products

- Support selection/award of Prime Contractor

- Define an architecture-based approach for Adaptive Planning

- Document agreed upon "fast track" approach to migration to NECC

ASP Navy Team

Chief Engineer: Rick Barbour

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ASP Navy Team – Strategy

Identify and focus on DoN priorities (e.g. Systems/Software Engineering, Open Architecture, Software Assurance)

Continue/Expand current funding with existing programs (DDG 1000, CG(X), PEO IWS, F-18, JSF, SIAP JPO, SPAWAR Systems Center Charleston (SSC-C))

Work with selected PMs and PEOs to improve their acquisition capabilities

- System and Software Architecture

- Process Improvement—System/Software Engineering and Acquisition

- Systems Interoperability

- DoD 5000 Acquisition Documents (SEP, TEMP, AS)

Develop opportunities to embed technical staff in Navy acquisition programs and PEOs

Develop senior Navy management advocacy (ASN RDA/RDA CHENG, DASN IWS, DASN RDT&E)

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Navy Example Engagement Results- [1]
Early/ Continuous Support to DDG 1000--Zumwalt Class Destroyer

Task:

- Technical support of the DDG 1000 Acquisition activities addressing evaluation of Design Agents (DA) contractor's approach, deliverables, plans, strategies & concepts

- Identify, evaluate and mitigate software acquisition risks

- Emphasis on software architecture evaluation, fault tolerance, real-time operations, resource management, COTS integration, software development and acquisition process, and technology transition

Strategy:

- Provide direct, ongoing support to acquisition program office

- Address early acquisition issues for Total Ship Computing Environment (TSCE)

TSCE has passed through multiple software releases and is nearing a production readiness milestone.

Navy Example Engagement Results- [2]
Early/ Continuous Support to DDG 1000--Zumwalt Class Destroyer

Accomplishments:

- SEI has been an integral part of this program for the past 8 years
  - Continuous support of the TSCEI Tech Team IPTs
    - Worked on Software Requirements for Release 5
    - worked with Raytheon architects to define system quality objectives in Release 6 vision
  - Consistent input on "Work Instruction Improvement" (e.g. Peer Review procedures)

- Support has focused on architecture technical analysis, fault tolerance practices and improved configuration and risk management

- Configuration Management analysis/recommendations supplied and accepted

- Continuing technical support in testing and acquisition support as program nears production

Navy Example Engagement Results- 3

Acquisition Strategy Development for Joint Strike Fighter

Task:

- Technical support of JSF Architectural Integrity, architectural related documentation and Technical Interchange Meetings and IPTs

- Support Identification of Risk and Technology Refreshment issues

- Provide independent, on-going, software engineering advisory expertise to JPO

Strategy:

- Provide direct, ongoing support to acquisition Joint Program Office

- Work closely with JPO and contractor

Architecture: using Quality Attribute definition and architecture evaluation practices on F-35 program
"…the [SEI architecture work] benefits the F-35 Joint Strike Fighter (JSF) Program...in evaluating our extensive system architecture (both airborne and ground-based)"

Mike Bossert, F-35 Air System Architect"

Navy Example Engagement Results- 4

Acquisition Strategy Development for Joint Strike Fighter

Accomplishments:

- Completed Technical System Architecture Assessments

- Completed Automated Logistics Information System (ALIS) Requirements Review

- Developed and published Quality Assessment of Software –Intensive System Architectures (QUASAR) Method CMU/SEI-2006-HB-001

- Developed Periodic Architecture Assessment Reporting System and Evaluation (PARSE) status methodology in use on program today

- Developed JSF specific Training materials for:

  - QUASAR

  - Modular Open Systems Approach (MOSA) and associated tool

  - Open Architecture and associated Open Architecture Assessment Tool

- Numerous reviews of JPO documents (e.g.) Requirements, Plans, Security

ASP Air Force Team

Chief Engineer: John Foreman

ASP Air Force Team – Strategy[1]

Impact Individual Programs

- Work directly with key acquisition programs to help them achieve their objectives. Emphasis on major acquisitions with PEO-based/product center focus.

  — **Currently:** Space (SMC) and Command and Control (ESC)

  — **Future:** aircraft and weapons

Impact Acquisition Organizations

- Maintain support from the Office of the Assistant Secretary of the Air Force for Acquisition (SAF/AQ) through work planned and executed in direct support of the Senior Acquisition Executive (SAE) to expedite the rapid transition of SEI-recommended best practices

ASP Air Force Team – Strategy$_2$

Define, Integrate, and Transfer Knowledge

- Disseminate lessons learned and best practices through courses, workshops, publications, and participation in acquisition communities of practice

- Look for and leverage commonality for the benefit of others

ASP Air Force Example Engagement Results[1]
Software Strategy and Expert Advice for TSAT

Task:

- Augmenting and enhancing the software engineering aspects of the program

- Providing expert advice and guidance on software engineering management, acquisition and technology

Strategy:

- Documented the way forward for TSAT in the "TSAT Recommended Software Strategy"

Accomplishments:

- Software IPT was reconstituted

- SWAMP has been written and approved

- System level software architecture is being developed based on segment data to help identify software risks and gaps across the system

ASP Air Force Example Engagement Results₂
Software Strategy and Expert Advice for TSAT

Customer Response:

- According to Col Moody:

"*The SEI team has truly been the conscience of software on the TSAT program. The Institute has provided detailed expertise in individual program segments, and is now helping the program with tools to avoid software pitfalls within the system.*"

"*From them, I get unflinching views from people who have seen the best and worst of software practices on large software-intensive programs.*"

ASP Intelligence Community Team

Chief Engineer: Rita Creel

ASP Intelligence Community Team – Strategy

Assist organizations throughout the Intelligence Community in improving outcomes of software-intensive systems acquisitions

- Directly support acquisition program offices, identifying risks and issues, recommending solutions, and providing needed expertise
- Work with agency- and directorate-level systems engineering and acquisition organizations to improve agency-wide policies and guidance
- Collaborate with the Office of the Director of National Intelligence (ODNI) on DNI policies affecting software

Establish an IC "Software Acquisition Community of Practice"

- Encourage collaboration on shared software concerns
- Define, integrate, and transfer knowledge

Enhance SEI ability to support Sensitive Compartmented Information (SCI) Programs

- Improve security practices and procedures
- Obtain sponsorship for more clearances
- Establish an SCI processing infrastructure

Intelligence Agencies – Themes

Educating the acquirer
Imparting requisite software knowledge to define, monitor, and manage a program; training and mentoring; effective teaming.

Advancing software-aware system engineering
Advising on requirements engineering and management; system architecting, design, construction, and integration; verification and validation; and sustainment and refresh techniques that suit complex environments.

Facilitating horizontal integration
Guiding the acquirer on development of robust architectures, interoperable systems, integration of disparate data, data mining, integrating the "enterprise," etc.

Overcoming process aversion
Communicating the value of process, modeling processes to identify inefficiencies and the need for improvement.

Overcoming technology aversion
Understanding prevalent attitudes, ensuring people are considered in technology solutions.

Tempering technology worship
Performing robust risk-benefit analyses, defining feasible off-ramps.

ASP Civil/Defense Agency Team

Chief Engineer: Steve Palmquist

ASP C&DA Team – Strategy

Help civil and defense agencies acquire and sustain software-intensive systems with predictable cost, schedule, and quality by

- Engaging with customers whose issues align with the goals of the SEI's technical initiatives

- Helping customers solve their current problems

- Growing the customer's ability to solve their future problems

- Reaching out to the larger software acquisition and development community through presentations, technical reports, and workshops

Civil & Defense Example Engagement Results
IRS Customer Account Data Engine (CADE)

Task:

- Initially asked by the program office to look at the use of a business rules engine (BRE) in CADE

- IRS Commissioner intervened to expand to a full Independent Technical Assessment (ITA) after the prime contractor missed a major deliverable

Strategy:

- In Congressional testimony, IRS Commissioner stated the SEI would assess the CADE program yearly, which we have supported (2003, 2004, 2006, & 2007; 2008 in planning)

- SEI is one of several organizations assessing CADE (Treasury IG, IRS Congressional Oversight)

Accomplishments:

- CADE program has met significantly more cost, schedule, and performance targets

Knowledge Integration and Transfer

Why is Software-Intensive Acquisition Hard?

Complex interactions between PMO, contractors, sponsors, and users
- Full chain of actions & their longer-term consequences are not clear
- Hard to apply corrective actions when status is uncertain

Significant delays exist between applying changes and seeing results
- Difficult to control systems with long delays between cause & effect
- *Example*: Steering an aircraft carrier

Unpredictable and unmanageable progress and results
- Limited visibility into real progress & status
- Complexity of interdependencies has unintended consequences

Uncontrolled escalation of situations despite best management efforts
- Misaligned goals can drive potentially conflicting behaviors

Linear partitioning is the standard approach to address large systems
- When systems have feedback between components that are partitioned, it makes it difficult to see & address these interactions

Exponential growth of interactions as size grows linearly

Acquisition Archetypes

ASP is producing a set of "Acquisition Archetypes" concept briefs, analyzing recurring patterns in actual acquisition programs, and recommending interventions and preventative actions

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What are the Acquisition Archetypes?

The Acquisition Archetypes depict the underlying structures of a set of dynamic behaviors that occur throughout acquisition organizations

- Each diagram tells a familiar, recurring story

- Each describes the structure that causes the dynamic

Acquisition Archetypes are used to:

- Identify failure patterns as they develop (recognition)

- Single out root causes (diagnosis)

- Engage in "big picture" thinking (avoid oversimplification)

- Promote shared understanding of problems (build consensus)

- Find interventions to break out of ongoing dynamics (recovery)

- Avoid future counter-productive behaviors (prevention)

Anatomy of an Archetype:
Causal Loop Diagrams

Depict qualitative "influencing" relationships (increasing or decreasing) and time delays between key variables that describe the system

Show relationship direction by labeling them **S**ame (**+**) or **O**pposite (**-**) to indicate how one variable behaves based on the previous variable

Consist primarily of two types of feedback loops:

- *__B__alancing – Changes to variables alternate, achieving equilibrium*

- *__R__einforcing – Changes to variables reinforce, moving in one direction*

Increases   **R**   *Increases*   *Increases*   **B**   *Decreases*
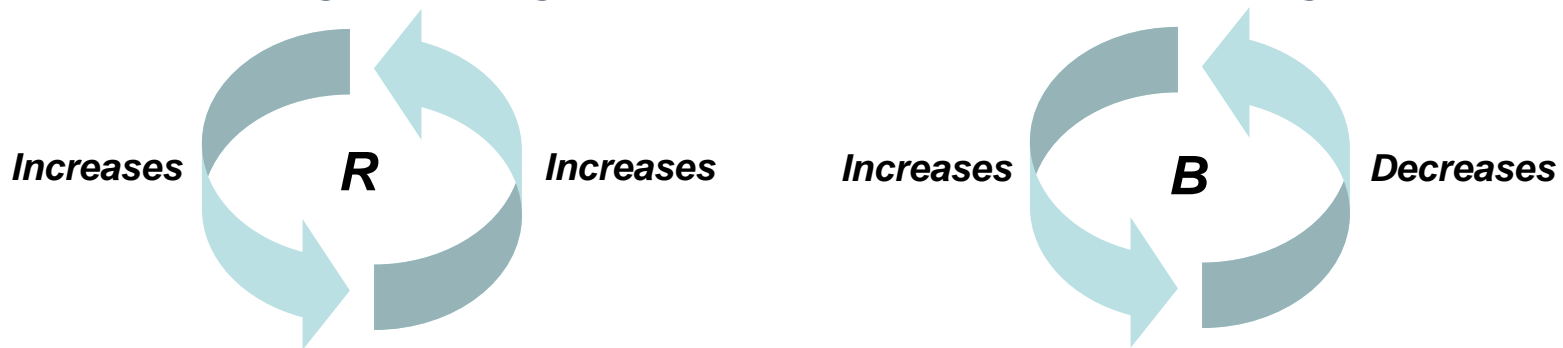
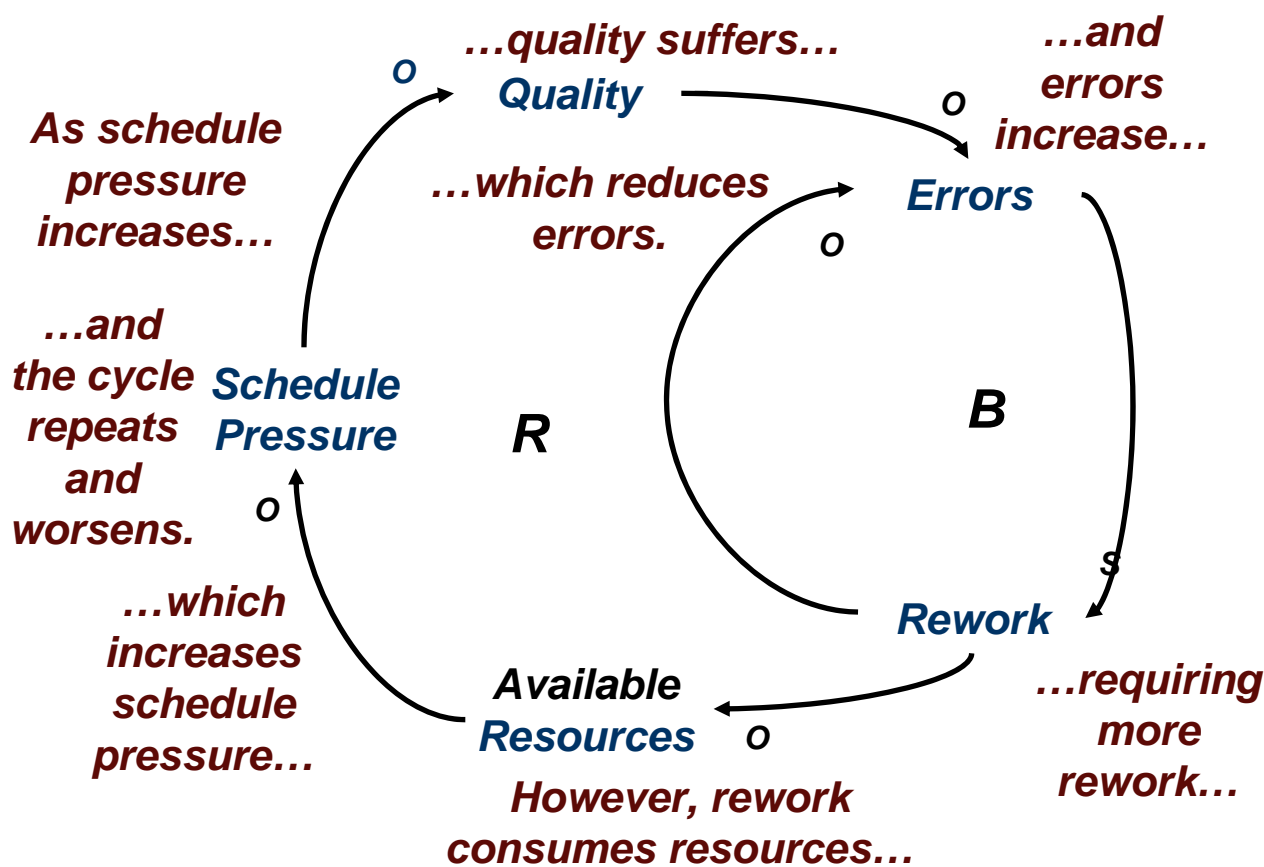# "Firefighting" – Acquisition Archetype
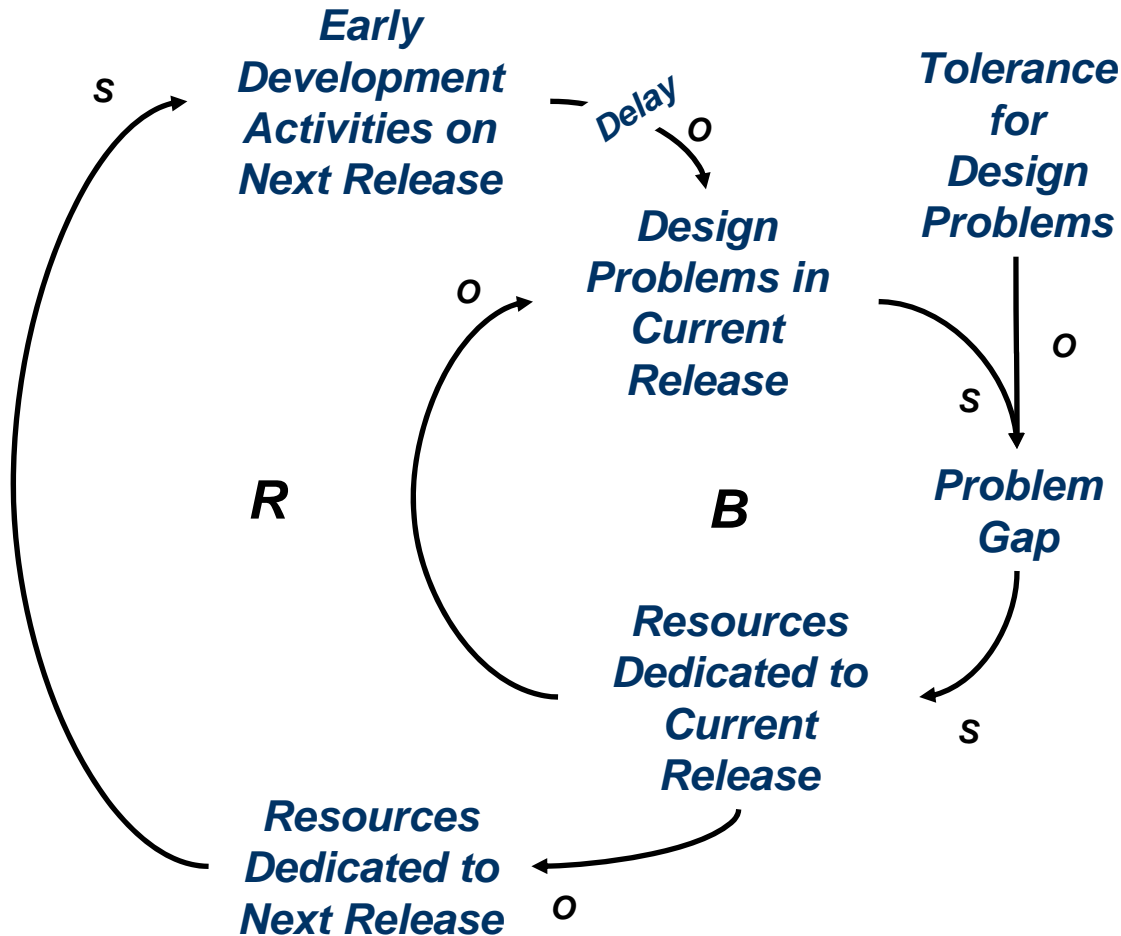
If design problems in the current release are higher than the tolerance for them, more resources must be dedicated to fix them. This reduces problems, but now fewer resources can work on the next release. This undermines early development activities which, after a delay, increases the number of design problems in the next release.

"Sacrificing Quality" – Acquisition Archetype

…quality suffers…
Quality

o

…and errors increase…

o

As schedule pressure increases…

…which reduces errors.

Errors

o

…and the cycle repeats and worsens.

Schedule Pressure

o

R

B

…which increases schedule pressure…

Rework

s

Available Resources

o

…requiring more rework…

However, rework consumes resources…

As schedule pressure increases, processes are shortcut, quality suffers, and errors increase—requiring more re-work. However, re-work consumes resources, which increases schedule pressure, and the cycle repeats and worsens.

Acquisition Archetypes

There are many recurring patterns of behavior in software acquisition and development that have been modeled using Systems Archetypes and CLDs:

- Sacrificing Quality
- Firefighting
- The "Bow Wave" Effect
- Underbidding the Contract
- Shooting the Messenger
- Robbing Peter to Pay Paul
- Longer Begets Bigger

      . . .

- The 90% Syndrome
- Requirements Scope Creep
- Feeding the Sacred Cow
- Brooks' Law
- PMO vs. Contractor Hostility
- Staff Burnout and Turnover
- The Improvement Paradox

      . . . .

Next Steps and Future Directions

Pattern Library of Acquisition Archetypes

- Eleven Acquisition Archetypes have been described
- Plan to identify additional acquisition dynamics & root causes

Collaborative Consulting

- Help customers identify program-specific, counter-productive behaviors

Learning Experiments

- Interactive "hands-on" exercises that demonstrate key dynamics in software acquisition programs

Acquisition Archetypes Workshop (2 days)

- "Improving Acquisition Practice and Avoiding Patterns of Failure"

Systems Engineering Effectiveness Survey (2004 – 2007)

Hypothesis: The effective performance of SE best practices on a development program yields quantifiable improvements in the program execution (e.g., improved cost performance, schedule performance, technical performance).

Objectives:

• Characterize effective SE practices

• Correlate SE practices with measures of program performance

Approach:

• Distribute survey to NDIA companies

• SEI analysis and correlation of responses

Survey Areas:

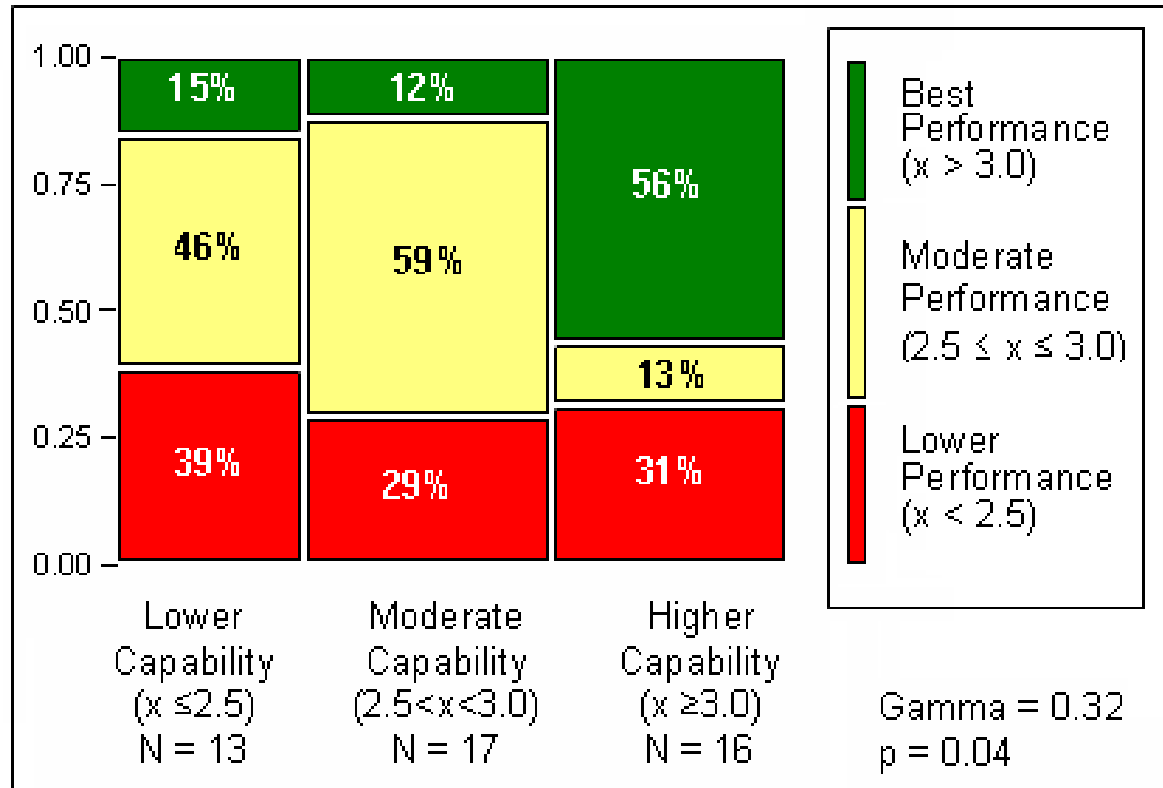|		
Process definition	Trade studies	Project reviews
Project planning	Interfaces	Validation
Risk management	Product structure	Configuration mgmt
Requirements development	Product integration	Metrics
Requirements management	Test and verification	
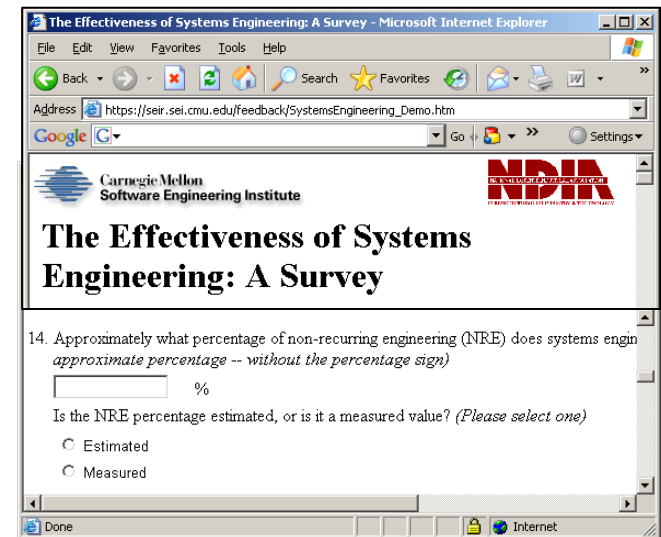
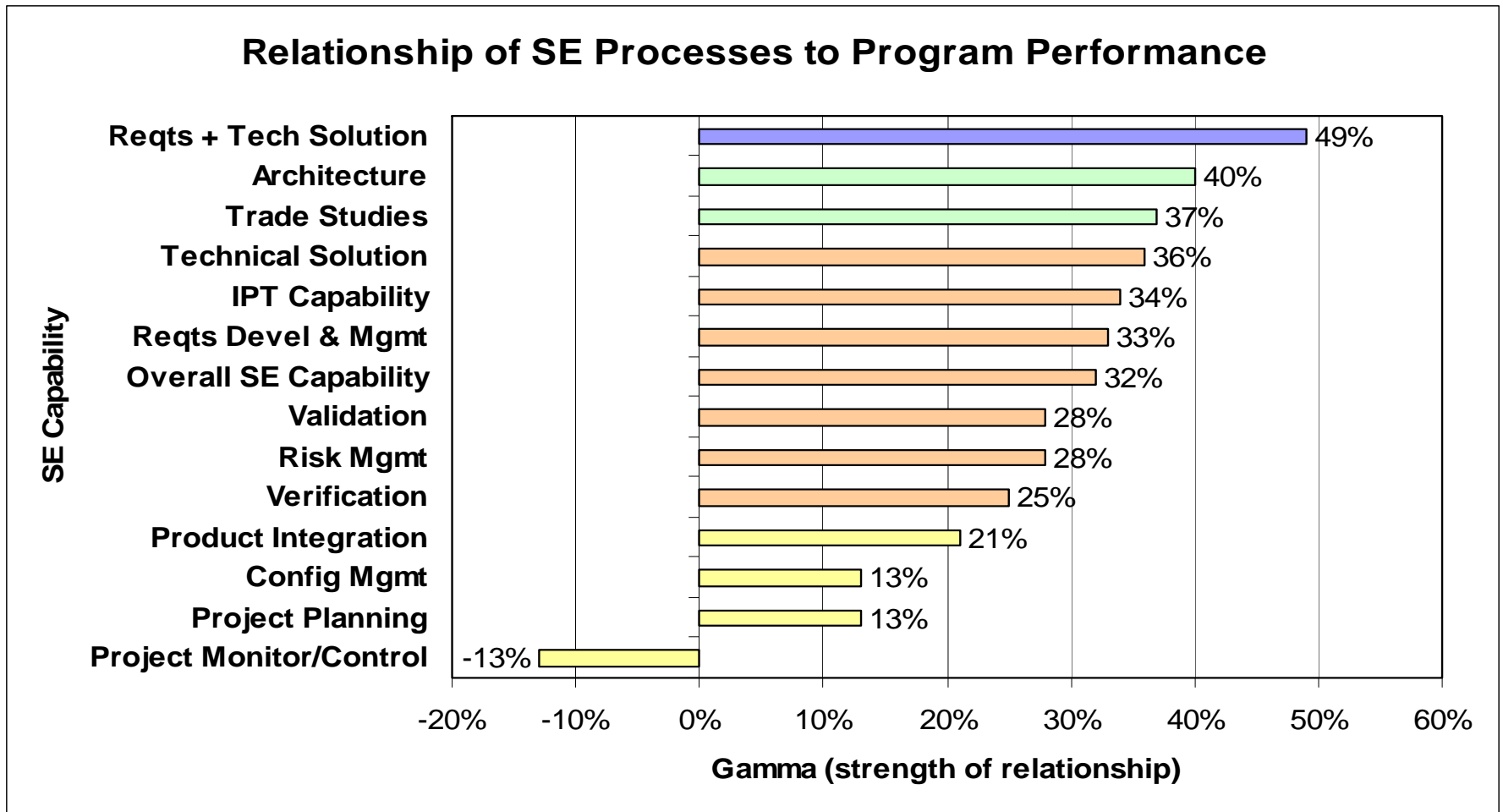# Total SE Capability (SEC) vs. Project Performance (Perf)

Projects with better Systems Engineering Capabilities deliver better Project Performance (cost, schedule, functionality)

Results: Summary of Relationships

Relationship of SE Processes to Program Performance

SE Capability (y-axis)

SE Capability	Gamma
Reqts + Tech Solution	49%
Architecture	40%
Trade Studies	37%
Technical Solution	36%
IPT Capability	34%
Reqts Devel & Mgmt	33%
Overall SE Capability	32%
Validation	28%
Risk Mgmt	28%
Verification	25%
Product Integration	21%
Config Mgmt	13%
Project Planning	13%
Project Monitor/Control	-13%

Gamma (strength of relationship) (x-axis: -20%, -10%, 0%, 10%, 20%, 30%, 40%, 50%, 60%)

Composite Measures

- *Strong Relationship*
- *Moderately Strong to Strong Relationship*
- *Moderately Strong Relationship*
- *Weak Relationship*

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ASP: Summary

The SEI, through the Acquisition Support Program, works directly with key acquisition programs to help them meet their objectives.

ASP looks for common themes and solutions and packages them for wider dissemination and use.

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For More Information

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